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(54) TDM/TDMA telecommunications system and method

TDM/TDMA-Übertragungssystem und Verfahren

Système et méthode de transmission TDM/TDMA

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WO-A-92/01341

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Description

[0001] This invention relates to telecommunications systems and in particular to systems employing the time division multiplex/time division multiple access (TDM/TDMA) principle.

BACKGROUND OF THE INVENTION

[0002] The TDM/TDMA principle is well known in radio systems or passive optical networks (PONs), where it is employed to permit transmission between a single base station and a plurality of outstations. In the downstream (base station to outstation) direction, the information (traffic) is broadcast to all outstations, but upstream it is transmitted in bursts, each of which must be timed to avoid mutual interference (overlap) so that at any time the base station only receives data from one outstation.

[0003] Specification No WO-A-9201341 discloses a method of enabling error free protection switching between two base stations in a telecommunications system and further discloses a downstream marshalling scheme. Specification No EP-A-0190771 discloses a method of establishing burst acquisition in a TDMA satellite communications system.

[0004] In our co-pending GB Applications 9223740.3 and 9223750.2 there are described time division multiple access frame alignment techniques for use in marshalling the transmission from newly connected outstations without interfering with existing traffic transmissions. The basic method of these applications comprises employing pseudo random sequences at a level below the noise sensitivity of the base station receiver (for normal traffic). These sequences can be detected using correlation and their phase is used to determine the loop delay to the new outstation. A sequence generator is required at the outstation, and a reference generator is required at the base station for correlation process. This is an upstream marshalling technique.

[0005] The present invention is concerned with protection of the base station.

SUMMARY OF THE INVENTION

[0006] According to the present invention there is provided a method of enabling error free or rapid protection switching between a main base station and a standby base station serving a plurality of outstations in a time division multiple access (TDMA) telecommunications system in which each outstation has binary sequence receiving means having a decision threshold for distinguishing ones and zeros in that binary sequence, which method employs a downstream marshalling scheme involving the transmission of a binary sequence from the standby base station to an outstation at levels below the noise sensitivity of a receiver at the outstation and alignment of the phases of the transmitted sequence and a reference main base station sequence in advance of switching between standby operation and main operation, said standby station binary sequence being superimposed on the main base station transmission, characterised in that the main base station transmission includes a marshalling window, that within the marshalling window the main base station transmits at approximately half power, and that the power output level of the main transmitter is adjusted within said marshalling window to a level corresponding to the decision threshold of the outstation receiving means whereby to effect detection of the standby base station sequence at the outstation.

[0007] According to another aspect of the invention there is provided an arrangement for enabling error free or rapid protection switching between a main base station and a standby base station serving a plurality of outstations in a time division multiple access (TDMA) telecommunications system in which each outstation has binary sequence receiving means having a decision threshold for distinguishing ones and zeros in that binary sequence, wherein a downstream marshalling scheme is employed involving the transmission of a binary sequence from the standby base station to an outstation at levels below the noise sensitivity of a receiver at the outstation and alignment of the phases of the transmitted sequence and a reference main base station sequence in advance of switching between standby operation and main operation, said standby station binary sequence being superimposed on the main base station transmission, characterised in that the main base station includes power level adjustment means for operating at approximately half power during a marshalling window provided in its transmission and for adjusting that power output to a level corresponding to the decision threshold of the outstation receiving means whereby to effect detection of the standby base station sequence at the outstation.

[0008] It is thus proposed to use an extension of a downstream marshalling technique in order to provide seamless protection i.e. enable switching from one base station to another. A downstream window can be used to capture samples. Initial alignment to the nearest bit can be achieved using exactly the same circuitry as for upstream marshalling. Samples can be stored at the outstations and processed thereat or at a base station. Duplicated traffic routes can be phase aligned either by allowing the marshalling technique to achieve it or, alternatively, if the phase discriminator of the marshalling system is modified to give an indication of the phase difference, alignment can be obtained more quickly.

[0009] In one embodiment of the invention, the main and standby base stations have identical frame synchronisation information, and the relative delay between the main transmitter sequence and a correlation sequence is used to determine the required standby transmitter timing.

[0010] The method may be applied to a burst mode system in which the downstream and upstream direc-

tions may share the same optical fibre and transmit in bursts so that at no time is a transmitter and receiver pair at an outstation or base station transmitting at the same time, and in respect of marshalling sequences upstream and marshalling sequences may be concurrent and continuous but orthogonal in nature or neither process will be concurrent in which case orthogonality is not required.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Embodiments of the invention will now be described with reference to the accompanying drawings in which:

Fig. 1 illustrates a PON network, and
Fig. 2 illustrates the optical signal at the receiver.

DESCRIPTION OF PREFERRED EMBODIMENT

[0012] The network illustrated in Fig. 1 comprises a base station 8 and three outstations 9, 10 and 11. Outstation 11 is drawn more explicitly than outstations 9 and 10 but all three are identical. This basic PON network and its function and the upstream marshalling technique is described in greater detail in the first above-mentioned co-pending application. The present invention is described hereinafter with reference to a PON network but it should be understood that it is equally applicable to a radio network or a twisted pair of coaxial cable network operating on TDMA principles.

[0013] The passive optical splitter 12, which includes a transmitter part and a receiver part, splits the signal out of a single transmitter e.g. TX1(1) into several receivers e.g. receiver 7 of outstation 11 so that the base station 8 can be carrying all of the traffic for everybody connected to it. With 32 outstations this can be up to six or seven hundred circuits, since each outstation can carry of the order of thirty channels. Hence quite often it is necessary to protect the base station by duplicating it. For the case where the base station electro-optical components have been duplicated as 1 and 2 the splitters 12 will be unchanged but there are now two fibres 3 and 4 running to it rather than just fibre 3. There is a need to be able to switch from one base station transmitter 1 to the other transmitter 2 and for this it is necessary for them to be perfectly synchronous and of similar amplitude, which would be the case if the fibres were exactly the same length and had the same loss. In practice this is not possible and thus some means is required to align their phases such as by means illustrated as variable delays 5. One way of doing this is to align the delays of the two fibres so that a receiver at an outstation can be switched instantaneously from one transmitter to the other, i.e. one base station to the other, so that operation can be continuous i.e. one transmitter is a hot standby transmitter. This can be achieved using a marshalling process with one (main) transmitter operating all the time. There is a small window in the downstream TDM frame structure of the main transmitter which is used for messaging but which is unused most of the time, and this window can be used to capture samples, alternatively a fixed window in the downstream frame may be reserved. The standby base station transmitter also transmits a low level transmission, which transmissions are similar to those described in the above-mentioned co-pending application as output by the outstation, which any of the outstations can receive and may store values (samples) of and possibly perform local processing on. However since the cost of a base station is amortised over all the outstations it is preferable to perform all the processing at the base station end of the system. The outstation stored values can be sent to the base station for processing using a dedicated channel or shared upstream channel, and processed by exactly the same circuitry that would be used for upstream marshalling as described in detail in the above-mentioned applications and thus by using the same techniques you can adjust the phase of the transmitted signal from one base station to the nearest bit at least, to be the same as the other base station. Having done that it is necessary to adjust the phase to within a bit for which there are three possible techniques. Technique 1 does not employ the marshalling process to achieve this since once the base stations have been switched over, the phase acquisition circuit 6 would acquire phase relatively quickly. Technique 2 uses the phase discriminator in the optical receiver of the outstation 7 modified to give an indication of exactly the phase difference between the phase of normal transmission and the phase of the offset one, for example by observing the location of zero crossings in a short burst of 10101010 traffic sent from the standby transmitter at normal amplitude, and if that is known the phase of the offset one can be modified so as to exactly align the phase and position in the frame of both of them. The third technique employs the coefficients of the correlators integrating the standby base station transmission. Hence phase alignment of duplicated traffic routes i.e. hot standby switchover is achieved. This is an extension of the marshalling technique of the above mentioned applications to allow hot standby protection switching without any error introduction.

[0014] Aspects of the downstream marshalling system used to obtain hot standby switchover will now be described in greater detail.

[0015] The amplitude of the low level transmitter sequence from the standby base station must be relatively small compared to that of the main base station transmission, in order that there is a negligible effect on the ability of an outstation to receive the main base station transmission free of error. For example, a ratio of approximately 10:1 in optical power is sufficient to meet this condition, although a greater ratio may be employed. Consequently during the downstream marshalling window in which the main transmitter output is tem-

porarily suspended, in order for the outstation to be able to detect the standby transmitted sequence, it is necessary for the outstation receiver threshold to be at the centre of the standby transmitter signal deviation. In order to achieve this it is necessary either to provide a special receiver design in which the outstation receiver threshold during the downstream marshalling window is able to adjust to the mean level of the signal during the window, or to design the main and standby transmitters in such a way as to allow this condition to be met. In a passive optical network employing this technique, it is advantageous to modify the transmitter rather than a multiplicity of receivers. This also allows the outstation receiver design to be entirely conventional, having a threshold recovery circuit that is adjusted to the mean of the optical data signal, which is normally binary. The method and means for achieving the requirement is as follows. Attention is directed to Fig. 2 in this respect.

[0016] During the downstream marshalling window, the main transmitter is set to approximately the half power level. An optical transmitter conventionally transmits at full power for a binary one and reduced power for a binary zero. The binary zero power is often that corresponding to the laser bias level, in which the laser is driven by a bias current, whilst the binary one level is determined by being driven by the bias current and a drive current. Thus to obtain half power the bias current is not altered but the drive current is halved. During the marshalling window, the optical signal received at each outstation will consist of the half power level of the main base station transmission, with the much lower standby transmitter sequence superimposed on it. This is illustrated in Fig. 2. The double headed arrows indicate the deviation of the received signal from the main transmitter due to the standby transmitter. In Fig. 2 the receiver decision threshold is a little too low, since the threshold during the downstream marshalling window is not at the centre of the deviation and is unlikely to produce any binary zeros.

[0017] In order to allow for the tolerance in the receiver decision threshold determined from the received signal, for deviation in the relationship between the laser drive current and output power, and tolerance in the laser drive circuit, a further technique for adjustment of the drive current of the main transmitter during the downstream marshalling window may be necessary. This takes the form of a control loop in which the ratio of ones and zeros received during the downstream marshalling window is determined and the transmitter drive current adjusted until this balances, this assuming equal probability of the number of ones and zeros in the standby correlation sequence. The mechanism for returning the outstation received data to the base station may employ a part of the PON TDMA upstream frame from that outstation, one method being to share the upstream messaging channel using the data received during a downstream marshalling window in place of a null message content. Since the correlation process operates over several thousand samples, the loss of some of these samples does not affect the function, but will increase the overall acquisition time.

[0018] The outstation receiver design is thus conventional and operation during the downstream marshalling window is thus no different from that elsewhere in the downstream frame, the sampled part of the downstream marshalling window may consist of only 8 bits of information, with a period of 16 bits either side to allow for the main transmitter to be switched from full to half power and half to full power, plus a short sequence of normal power alternating one/zero transmission prior to and after the marshalling window to ensure timing recovery circuits remain in good alignment in respect of the main transmitter.

[0019] In the downstream marshalling method the main and standby transmitters will be given the same frame synchronisation reference information in order that the relative delay between the main transmission sequence to the outstation, which will contain framing information, for example in the form of a CRC in a fixed position, and the correlation sequence position can be used to determine the required standby transmitter transmit time. In order to determine the required transmit phase angle for the standby transmitter (phase angle being defined as the fraction of a transmitted bit) in addition to the delay in bits between the two paths (main to receiver and standby to receiver), employing technique 3 referred to earlier it is sufficient to determine the correlation coefficients of two correlators spaced one bit apart in respect of the reference sequence. If the standby transmitted sequence is not an exact number of data bits (in delay terms e.g. 1 bit at 50MHz represents a delay of 20 nanoseconds representing a differential transmission distance of 4 metres) then the sampled sequence will be comprised of samples in which components from the two adjacent bits from the standby transmitter exist. Conversely, each element transmitted by the standby transmitter will have a component in two adjacent receiver samples. When averaged (integrated) over sufficient received bits, the ratio of the adjacent correlation coefficients will give the degree of offset of the bit boundary. This may be adjusted by means of an adjustable tapped delay line at the standby transmitter until there is no overlap of coefficients. The outstation receiver in the conventional case will detect a binary one or binary zero, hence if the phase error relative to the bit boundary is small, the larger signal component will dominate and potentially totally obscure the smaller signal component, preventing the assessment of the ratios of adjacent correlator coefficients. Where the received standby sequence is comparable with or smaller than transmitter correlation sequence level is comparable with the noise level of the receiver, this limiting effect will not apply. However if this is not the case, an alternative is to deliberately adjust the phase of the standby transmitted sequence to generate equal components in adjacent samples. When the standby transmitter is

switched to become the main transmitter, the required phase angle and bit offset is applied.

[0020] During standby operation, once the relative position of the transmitter has been found, short bursts of normal amplitude data may be transmitted in the marshalling window to enable verification and full power adjustment of the standby transmitter.

Claims

1. A method of enabling error free or rapid protection switching between a main base station (1) and a standby base station (2) serving a plurality of outstations (9,10,11) in a time division multiple access (TDMA) telecommunications system in which each outstation has binary sequence receiving means (7) having a decision threshold for distinguishing ones and zeros in that binary sequence, which method employs a downstream marshalling scheme involving the transmission of a binary sequence from the standby base station to an outstation at levels below the noise sensitivity of a receiver at the outstation and alignment of the phases of the transmitted sequence and a reference main base station sequence in advance of switching between standby operation and main operation, said standby station binary sequence being superimposed on the main base station transmission, characterised in that the main base station transmission includes a marshalling window, that within the marshalling window the main base station transmits at approximately half power, and that the power output level of the main transmitter is adjusted within said marshalling window to a level corresponding to the decision threshold of the outstation receiving means whereby to effect detection of the standby base station sequence at the outstation.

2. A method as claimed in claim 1, characterised in that the phase alignment is achieved by a correlation process.

3. A method as claimed in claim 2, characterised in that the main and standby base stations have identical frame synchronisation information, and that the relative delay between the main transmitter sequence and a correlation sequence is used to determine the required standby transmitter timing.

4. A method as claimed in any one of the preceding claims wherein the base stations each include a respective transmitter which is transmitting continuously, the base station acting as a main base station at a particular point in time transmitting at a higher power than the base station acting as a standby base station at that time.

5. A method as claimed in any one of claims 1 to 4, characterised in that the ratio of transmitted powers of the main and standby base stations is of the order of 10:1.

6. A method as claimed in any one of claims 1 to 5, characterised in that the telecommunications system is a passive optical network (PON) system and that the transmitters comprise optical sources,

7. An arrangement for enabling error free or rapid protection switching between a main base station (1) and a standby base station (2) serving a plurality of outstations (9,10,11) in a time division multiple access (TDMA) telecommunications system in which each outstation has binary sequence receiving means (7) having a decision threshold for distinguishing ones and zeros in that binary sequence, wherein a downstream marshalling scheme is employed involving the transmission of a binary sequence from the standby base station to an outstation at levels below the noise sensitivity of a receiver at the outstation and alignment of the phases of the transmitted sequence and a reference main base station sequence in advance of switching between standby operation and main operation, said standby station binary sequence being superimposed on the main base station transmission, characterised in that the main base station includes power level adjustment means for operating at approximately half power during a marshalling window provided in its transmission and for adjusting that power output to a level corresponding to the decision threshold of the outstation receiving means whereby to effect detection of the standby base station sequence at the outstation.

Patentansprüche

1. Verfahren zu Ermöglichung einer fehlerfreien oder schnellen Schutzumschaltung zwischen einer Haupt-Basisstation (1) und einer Reserve-Basisstaion (2), die eine Vielzahl von Aussenstationen (9,10,11) in einem Zeitviefachzugriffs-(TDMA-) Telekommunikationssystem bedienen, bei dem jede Aussenstation eine Binärsequenz-Empfangseinrichtung (7) mit einem Entscheidungs-Schwellenwert zur Unterscheidung von Eins- und Null-Werten in dieser Binärsequenz aufweist, wobei das Verfahren ein Abwärts-Einreihungsschema verwendet, das die Übertragung einer Binärsequenz von der Reserve-Basisstation zu einer Aussenstation mit Pegeln unterhalb der Rauschempfindlichkeit eines Empfängers an der Aussenstation und die Ausrichtung der Phasen der übertragenen Sequenz und einer Haupt-Basisstations-Bezugssequenz vor der Umschaltung zwischen dem Reservebetrieb und

dem Hauptbetrieb beinhaltet, wobei die Binärsequenz der Reservestation der Aussendung der Haupt-Basisstation überlagert wird, dadurch gekennzeichnet, dass die Aussendung der Haupt-Basisstation ein Einreihungsfenster einschließt, dass innerhalb des Einreihungsfensters die Haupt-Basisstation mit ungefähr der halben Leistung sendet, und dass der Ausgangsleistungspegel des Hauptsenders innerhalb des Einreihungsfensters auf einen Pegel eingestellt wird, der dem Entscheidungs-Schwellenwert der Aussenstations-Empfangseinrichtung entspricht, wodurch eine Erfassung der Sequenz der Reserve-Basisstation an der Aussenstation bewirkt wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die Phasenausrichtung durch einen Korrelationsprozess erzielt wird.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, dass die Haupt- und Reservebasisstationen eine identische Rahmensynchronisationsinformation haben, und dass die relative Verzögerung zwischen der Haupt-Sendersequenz und einer Korrelationssequenz zur Bestimmung der erforderlichen Reserve-Senderzeitsteuerung verwendet wird.

4. Verfahren nach einem der vorhergehenden Ansprüche, bei dem die Basisstationen jeweils einen jeweiligen Sender einschliessen, der kontinuierlich sendet, wobei die zu einem bestimmten Zeitpunkt als Haupt-Basisstation wirkende Basisstation mit einer höheren Leistung sendet, als die zu dieser Zeit als Reserve-Basisstation arbeitende Basisstation.

5. Verfahren nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass das Verhältnis der ausgesandten Leistungen der Haupt- und Reserve-Basisstationen in der Grössenordnung von 10:1 liegt.

6. Verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, dass das Telekommunikationssystem ein passives optisches Netzsystem (PON) ist, und dass die Sender optische Quellen umfassen.

7. Anordnung zur Ermöglichung einer fehlerfreien oder schnellen Schutzumschaltung zwischen einer Haupt-Basisstation (1) und einer Reserve-Basisstation (2), die eine Vielzahl von Aussenstationen (9,10,11) in einem Zeitvielfachzugriffs-(TDMA-) Telekommunikationssystem bedienen, bei dem jede Aussenstation eine Binärsequenz-Empfangseinrichtung (7) mit einem Entscheidungs-Schwellenwert zur Unterscheidung von Eins- und Null-Werten in dieser Binärsequenz aufweist, wobei ein Abwärts-Einreihungsschema verwendet wird, das die Aussendung einer Binärsequenz von der Reserve-Basisstation zu einer Aussenstation mit Pegeln unterhalb der Rauschempfindlichkeit eines Empfängers an der Aussenstation und die Ausrichtung der Phasen der ausgesandten Sequenz und einer Haupt-Basisstations-Bezugssequenz vor dem Umschalten zwischen dem Reservebetrieb und dem Hauptbetrieb beinhaltet, wobei die Binärsequenz der Reservestation der Aussendung der Haupt-Basisstation überlagert wird, dadurch gekennzeichnet, dass die Haupt-Basisstation Leistungspegel-Einstelleinrichtungen zum Betrieb bei ungefähr der halben Leistung während eines Einreihungsfensters, das in ihrer Aussendung vorgesehen ist, und zur Einstellung dieser Ausgangsleistung auf einen Pegel beinhaltet, der dem Entscheidungs-schwellenwert der Aussenstations-Empfangseinrichtung entspricht, wodurch eine Erfassung der Reserve-Basisstations-Sequenz an der Aussenstation bewirkt wird.

Revendications

1. Procédé destiné à permettre une commutation avec protection rapide ou sans erreur entre une station de base principale (1) et une station de base de secours (2) qui desservent plusieurs stations externes (9, 10, 11) dans un système de télécommunications à accès multiple par répartition dans le temps (TDMA), dans lequel chaque station externe possède un dispositif (7) de réception d'une séquence binaire ayant un seuil de décision destiné à distinguer les 1 et les 0 dans cette séquence binaire, et le procédé met en oeuvre un schéma de tri aval qui comprend la transmission d'une séquence binaire par la station de base de secours vers une station externe avec des niveaux inférieurs à la sensibilité au bruit d'un récepteur de la station externe et l'alignement des phases de la séquence transmise et d'une séquence de station de base principale de référence avant la commutation entre l'opération avec la station de secours et l'opération avec la station principale, la séquence binaire de la station de secours étant superposée à la transmission de la station principale de base, caractérisé en ce que la transmission de la station principale de base comprend une fenêtre de tri, en ce que, pendant la fenêtre de tri, la station principale de base transmet à demi-puissance approximativement, et en ce que le niveau de puissance de sortie de l'émetteur principal est ajusté dans la fenêtre de tri à un niveau qui correspond au seuil de la décision exécutée au dispositif de réception de la station externe, pour assurer la détection de la séquence de la station de base de secours à la station externe.

2. Procédé selon la revendication 1, caractérisé en ce que l'alignement de phase est obtenu par une opération de corrélation.

3. Procédé selon la revendication 2, caractérisé en ce que les stations de base principale et de secours ont des informations identiques de synchronisation de trames, et en ce que le retard relatif de la séquence de l'émetteur principal et d'une séquence de corrélation est utilisé pour la détermination de la synchronisation nécessaire de l'émetteur de secours.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel les stations de base comportent chacune un émetteur respectif qui transmet de façon continue, la station de base jouant le rôle, à un moment particulier, d'une station principale de base qui transmet avec une puissance plus élevée que la station de base jouant le rôle de la station de base de secours à ce moment.

5. Procédé selon l'une quelconque des revendications 1 à 4, caractérisé en ce que le rapport des puissances émises par les stations de base principale et de secours est de l'ordre de 10/1.

6. Procédé selon l'une quelconque des revendications 1 à 5, caractérisé en ce que le système de télécommunications est un système à réseau optique passif (PON), et les émetteurs comprennent des sources optiques.

7. Ensemble destiné à permettre une commutation rapide ou sans erreur avec protection entre une station de base principale (1) et une station de base de secours (2) desservant plusieurs stations externes (9, 10, 11) dans un système de télécommunications à accès multiple par répartition dans le temps (TDMA) dans lequel chaque station externe a un dispositif (7) de réception d'une séquence binaire ayant un seuil de décision destiné à distinguer les 1 et les 0 dans cette séquence binaire, dans lequel un schéma de tri aval est utilisé et comprend la transmission d'une séquence binaire de la station de base de secours à une station externe à des niveaux inférieurs à la sensibilité au bruit d'un récepteur placé à la station externe et l'alignement des phases de la séquence transmise et d'une séquence de référence de station de base principale avant la commutation entre l'opération de secours et l'opération principale, la séquence binaire de la station de secours étant superposée à la transmission de la station de base principale, caractérisé en ce que la station de base principale comporte un dispositif d'ajustement du niveau de puissance destiné à travailler à un niveau approximativement moitié de puissance pendant une fenêtre de tri formée dans sa transmission, et d'ajustement du niveau de puissance de sortie à une valeur qui correspond au seuil de décision du dispositif de réception de la station externe, afin que la détection de la séquence de la station de base de secours soit effectuée à la station externe.

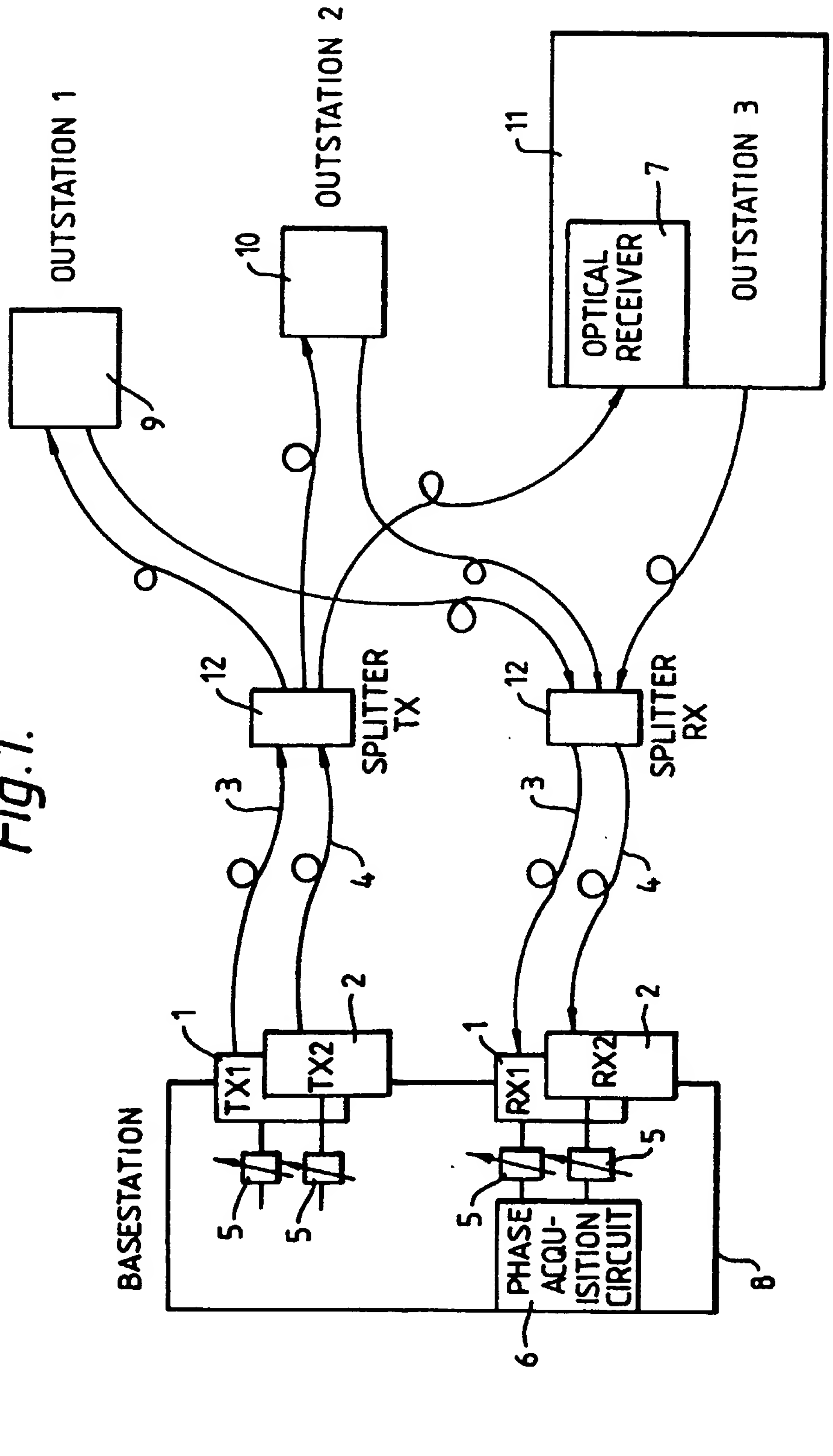
BASESTATION
TX1
TX2
RX1
RX2
PHASE ACQU- ISITION CIRCUIT
SPLITTER TX
SPLITTER RX
OUTSTATION 1
OUTSTATION 2
OUTSTATION 3
OPTICAL RECEIVER
1
2
3
4
5
6
7
8
9
10
11
12

Fig.1.

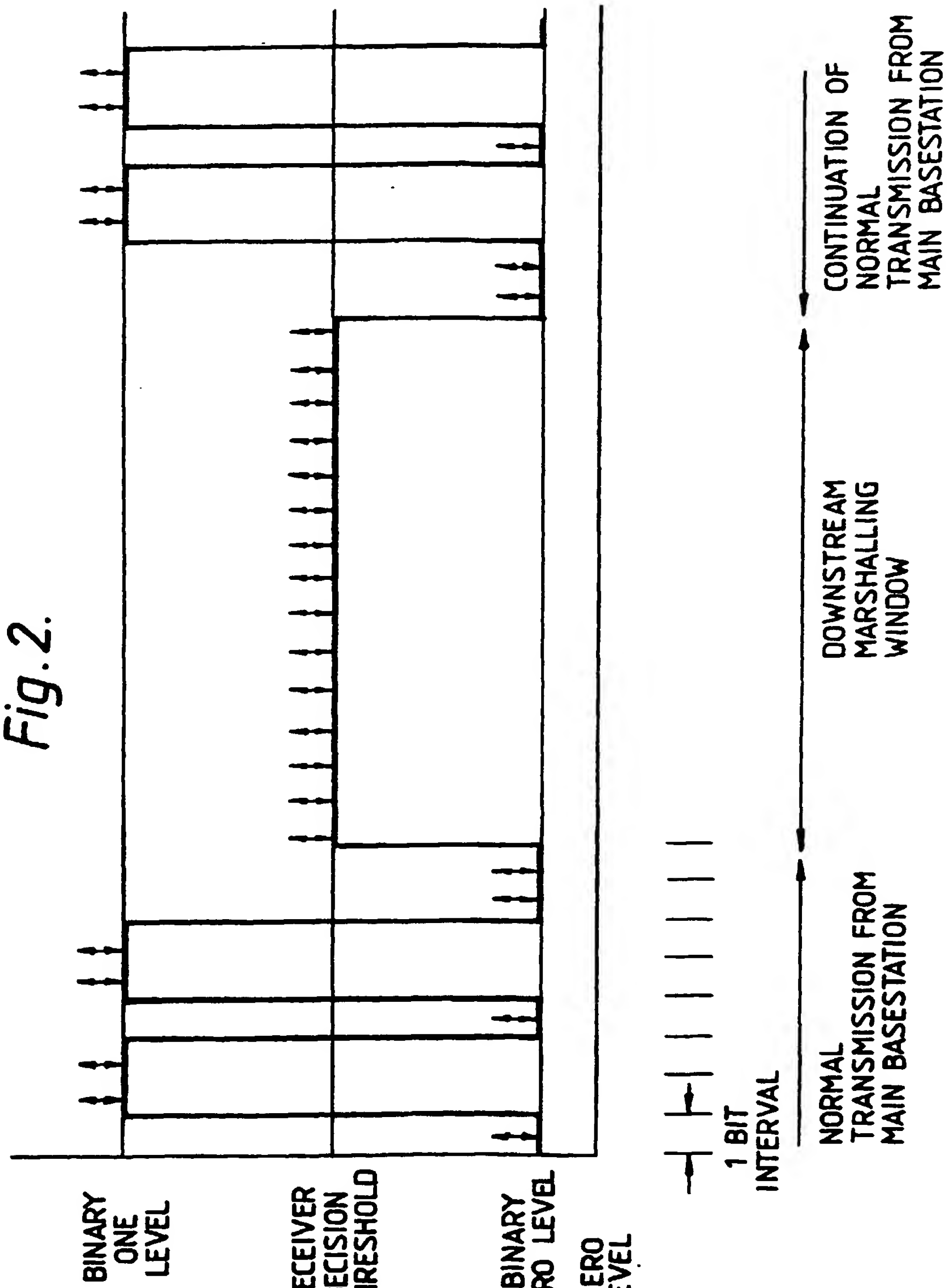
BINARY ONE LEVEL
RECEIVER DECISION THRESHOLD
BINARY ZERO LEVEL
ZERO LEVEL
1 BIT INTERVAL
NORMAL TRANSMISSION FROM MAIN BASESTATION
DOWNSTREAM MARSHALLING WINDOW
CONTINUATION OF NORMAL TRANSMISSION FROM MAIN BASESTATION

Fig. 2.